Mobilization of Copper and Antimony in Bottom Ash Landfills

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Introduction

The deposition of bottom ash from Swiss municipal solid waste incineration (MSWI) plants raises questions regarding its environmental compatibility, which not yet have been answered. The deposited bottom ashes and fly ashes have elevated concentrations of chemical compounds, which are regarded as toxic and dangerous for the environment .Within the framework of a dissertation in our group, various bottom ash landfills with deposits of different ages are being investigated to establish a basis for hydraulic and geochemical modelling. Beside leachate monitoring, several drilling campaigns are carried out in different landfills. While the model is mainly based on hydraulic data from the cores, the study presented here focuses on geochemical processes. With Cu and Sb two elements are investigated, which, due to their different geochemical and aquatic properties, are suitable as optimal substitutes for a variety of heavy metals (free cations and oxyanions). In addition to dissolution mechanisms, the study of mineralogy, speciation, and the identification of potential retention effects are of main interest.

Aim of this work:

- Developing a better understanding of the mobilization of Cu and Sb in bottom ash landfills using samples gained from drilling cores
- Development of processing and analytical methods for material characterisation of bottom ash

Background

Mobilization of Cu

Cu mobilization:

- Mainly influenced by pH, redox system, complexation and sorption effects
- Influenced by dissolved organic carbon (DOC) via complexation processes

Legal situation and monitoring

- Legal limit of Cu concentration in sewage system discharge waters is 1 mg/L
- Landfill operators obliged to monitor the leachate
- Therefore a good data set for Cu is available

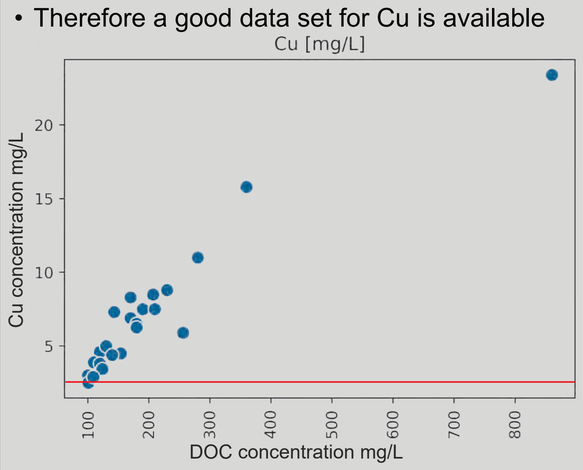


Figure 1: Cu concentrations and DOC concentrations in leachate with the legal discharge limit of Cu indicated as red line (Wiedag Recycling AG)

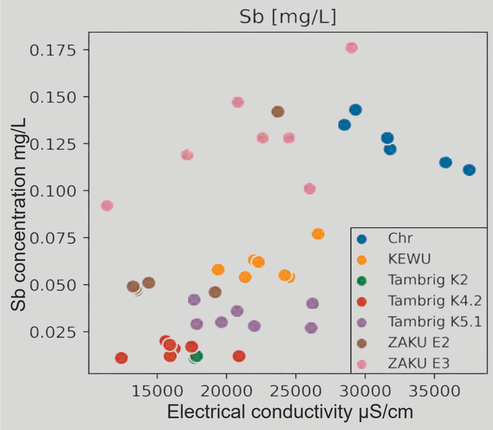
Mobilization of Sb

Sb mobilization:

- At pH >10, dissolution dependant on Sb-Ca solid solution formation
- At pH 8-9, sorption effects with Fe and Al hydroxides come to play

Legal situation and monitoring

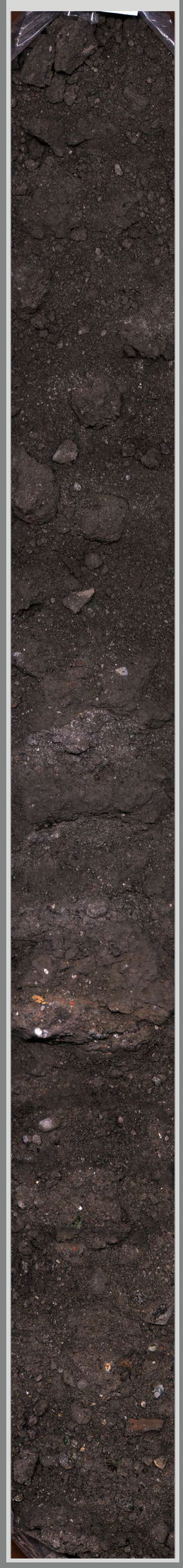
- Contrary to other heavy metals (e.g. Cu, As) Sb has no legal limit for sewage system discharge
- Therefore landfill operators are not obliged to include Sb in the monitoring programs



- In leachate analysis Sb concentrations up to 0.2 mg/L were measured
- For comparison, the As legal limit is 0.1 mg/L

Figure 2: Sb concentration and electrical conductivity in leachate of different landfills (Philip Ingold)

Line Scan



Drilling Campaign

Core Sampling and Processing

Core sampling:

- Cores were catched inside the drilling rod and taken for every meter using the pneumatic cylinder on the side of the drilling machine

Challenges of the drilling process:

- Due to the friction of the drill head, the temperature rose up to 85°C, raising the question how this influences the mineralogical composition of the cores

Figure 3: Core drilling device on site with the pneumatic core removal cylinder on the right

Core processing and sampling:

- Halving of the core, using the upper halve for water content and grain size distribution samples
- The lower halve got prepared to be taken to a line scan camera to get high resolution imaging done (see core scan on the right)
- After scanning, samples for the chemistry and mineralogy were taken from the core, dried (40°C for XRD, 105°C for XRF) and milled using a vibratory disc mill

Challenges during processing

- While the ash segments of the cores ash layers of the cores were easy to prepare and halve, the bottom ash segments posed more of a challenge
- Hard sections consisting of carbonatisations and aggregated silicatic materials as well as scrap metal parts had to be worked with some force
- The milling of the XRD and XRF samples could not be satisfactorily accomplished. The used mill was not able to grind down all of the material to below 100 µm

Figure 4: Intersection of core with the dark layer created by friction visible

Eluates

Batch Eluate Test

Aim

- Measuring the total pollution potential
- Applying method according to the Swiss Waste Legislation (VVEA)

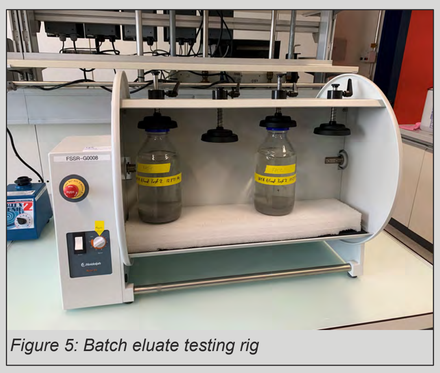


Figure 5: Batch eluate testing rig

Procedure

- Test 1 (heavy metals): during 24h, CO_2 gets injected into a suspension of solid sample and deionised water
- Test 2 (oxyanions and DOC): The suspension of solid sample and deionised water is overhead shaked for 24h

Column Eluate Test

Aim:

- Determination of the mobilization potentials of Cu and Sb
- The test gets carried out to the European Standard CEN/TS 14405

Procedure

- Samples are placed a glass column
- The test is performed in 3 steps:
  - Saturation: The column is flown trough from bottom to top with deionised water
  - Equilibration: The column rests for 72h
  - Elution: The material is eluted and the eluate is collected in 7 fractions over the span of 27 days

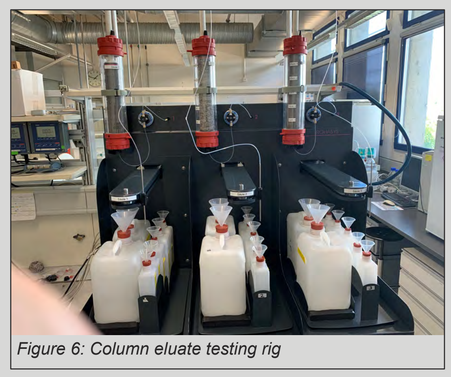


Figure 6: Column eluate testing rig

Outlook

The following work is planned for the remainder of the project:

- Execution of the laboratory test of the first 2 cores
- Second drilling campaign in April; same procedure as with the first core
- Description of alteration processes based on solid characterization and eluate behavior
- Evaluation of existing leachate data, searching for correlations of Sb and Cu with other species

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